

Keraocarpon gen. nov., magnolialean fruits from the Upper Cretaceous of Hokkaido, Japan

TAMIKO OHANA¹, TATSUAKI KIMURA¹ and SHYA CHITALEY²

¹Institute of Natural History, 24-14-3 Takada, Toshima-ku, Tokyo 171-0033, Japan

²Cleveland Museum of Natural History, 1 Wade Oval Drive, University Circle, Cleveland, Ohio 44106-1767, U.S.A.

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Abstract. Two new permineralized magnolialean fruits derived from the Coniacian–Santonian strata of the Upper Yezo Group are described in this paper. Each fruit consists of floral head, convex receptacle and woody peduncle. Floral head consists of many conduplicate follicles with adaxial opening. Follicle is long stalked, unilocular and many seeded. Since the fruits differ from the already known ones of Magnoliales, a new genus *Keraocarpon* is proposed to include two new species, *K. yasujii* and *K. masatoshihi*. A brief comparison of *Keraocarpon* to other magnolialean taxa is made. These two new species are distinguished from each other by the differences in size of various elements, number of follicles in the aggregate fruits, number of seeds per follicle, and other minor characters. The genus is characterized by aggregate fruits of many-seeded apocarpous stalked follicles on a slightly convex receptacle.

Key words: Aggregate fruits, follicle, Hokkaido, Japan, *Keraocarpon*, Magnoliales, Upper Cretaceous

Introduction

In 1980, Yasuji Kera collected a permineralized specimen of a magnolialean fruit from an ammonite-bearing floated nodule in the Kumaoizawa (brief map, see Ohana and Kimura, 1993, fig. 1), Mikasa City, Hokkaido. Around this locality, the fossiliferous Yezo Group of marine origin is exposed, and the coexisting ammonites indicate a Coniacian–Santonian age (Ohana and Kimura, 1991).

This specimen was briefly described by Ohana and Kimura (1987) as an unnamed magnolialean flower. Masatoshi Kera collected later a smaller specimen of the same kind along the bank in the upper course of the Ikushunbetsu River, which might be derived from the Upper Yezo Group.

After an extensive study of these specimens, this paper now describes them in detail as new fruits under a new name *Keraocarpon* gen. nov. Ohana, Kimura and Chitaley, with description of two new species *K. yasujii* and *K. masatoshihi*. The genus and species described here have seeds inside the follicles and thus a new generic name *Keraocarpon* is better suited, instead of *Keranthus*.

Materials and methods

Both the fruits are permineralized. Their cells and minor structures are partly disintegrated by the subsequent crystallization of calcite. Two permineralized specimens are cut as indicated by arrows in Figure 2–2 and Figure 5–2.

Cutting surfaces were polished with carborundum abrasive and then etched with diluted HCl for half a minute. Peels on

cellulose-acetate film were taken from the etched surfaces after washing off the acid with water. Cellulose-acetate film 0.034 mm thick (Bioden, R. F. A., Oken Co., Tokyo) was used to make the peel sections.

The specimens and their peel sections are kept at the Institute of Natural History, Tokyo (INH).

Systematic description

Class Magnoliopsida

Order Magnoliales (Family unknown)

Keraocarpon Ohana, Kimura and Chitaley gen. nov.

Etymology.—After Y. Kera who collected the type specimen of *Keraocarpon yasujii*.

Type species.—*Keraocarpon yasujii* Ohana, Kimura and Chitaley sp. nov.

Generic diagnosis.—*Keraocarpon* is a member of the woody polycarpous aggregated group of magnolialean fruit. Follicles stalked, many-seeded and spirally arranged on the receptacle.

Keraocarpon is unique in external form but vegetative parts and male organs are unknown. In transverse section, stalks have a large central pith, collateral bundles, and thin inner and thick outer cortices. The bundles consist of vascular elements with scalariform thickenings. Seeds: The follicle unilocular with many seeds alternately arranged in two rows. Seed coat thick with micropyle facing the adaxial suture of the follicle.

Remarks.—The new magnolialean genus *Keraocarpon* is

distinguishable from other magnolialean fossil genera with apocarpous and conduplicate follicles (e. g. *Archaeanthus*; Dilcher and Crane, 1984) in having a long receptacle. *Lesqueria* (Crane and Dilcher, 1984) has an ovoid receptacle and bifid distal end of the follicle. *Protomonimia* has a concave receptacle and sessile follicles (Nishida and Nishida, 1988).

Recently, a magnolialean fructification was reported by Nishida *et al.* (1996) from the Upper Cretaceous of Hokkaido. According to them, it has more than 170 short-stalked apocarpous and adaxially sutured follicles on the slightly concave receptacle. Follicle has a single dorsal and a pair of ventral strands. The authors created a new genus *Hidakanthus* on the basis of their single specimen. Externally *Keraocarpon* differs from *Hidakanthus* with longitudinally compressed floral head and with short, strongly falcate follicles in the latter.

In addition we could not make a detailed comparison of *Keraocarpon* with *Hidakanthus*, because in the latter no seeds are preserved in the follicle, and printed scales were omitted in all photographic figures (see Nishida *et al.*, 1996, Figures 2-13).

Keraocarpon yasujii Ohana, Kimura and Chitaley, sp. nov.

Figures 1A, 2, 3, 4

Unnamed magnolialean flower with apocarpous follicles in Ohana and Kimura, 1987 p. 175, figures 1A-J.

Specimen.—INH-020 (holotype).

Locality.—Kumaozawa (roughly 142°27'E, 42°42'N), Mikasa City, Hokkaido.

Horizon.—Coniacian-Santonian, Upper Yezo Group.

Etymology.—After Yasuji Kera, collector of the holotype.

Specific diagnosis.—Aggregate fruits large-sized. Receptacle slightly convex, disk-like. Follicles around 470, helically arranged; each follicle 2.4 cm long and 2.0 mm wide. Seeds numerous, 21-24 in each follicle.

Description.—Peduncle: The preserved part is 2.2 cm long and 1.2 cm or more in diameter (Figure 2-2A) consisting of a parenchymatous central pith, 5.0 mm in diameter, surrounded by collateral vascular bundles, 1.7 mm each, and cortex, about 1.7 mm wide. The vascular bundles are arranged concentrically, and include secondary xylem with scalariform vessels, and annular or pitted tracheids. The outer cortex consists mainly of sclerenchymatous cells which are in vertical ribs about 10 rows deep (Figure 2-3, arrows; Figure 4-7). Large cells (possibly resin cells) elliptical in cross section, 0.5 mm in major diameter, are scattered in the cortex; lining cells are not observed (Figure 4-7).

Receptacle: The receptacle is disk-like, slightly convex centrally, 2.7 cm in diameter and more than 6.5 mm thick, consisting mainly of parenchymatous cells and a number of slender fibrous bundles running vertically and horizontally (Figure 2-2B; Figure 4-8, 9).

Follicles: The follicles are numerous and helically arranged (Figure 2-2D; Figure 2-5, 6). Parastichy is uncertain, because nearly half of aggregate fruits is missing. The estimated number of follicles is 470 or fewer. The follicles

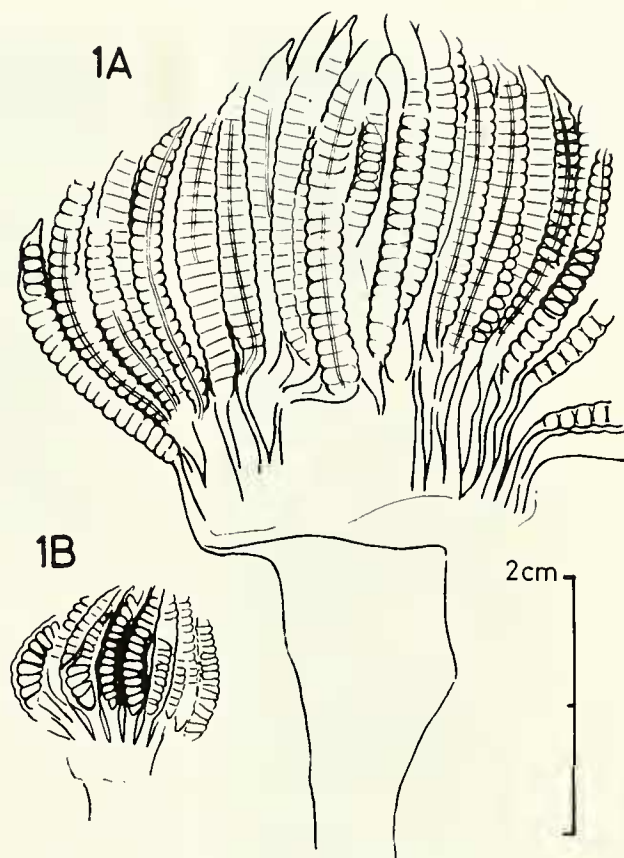


Figure 1. Longitudinally broken fruits. **1A**: *Keraocarpon yasujii* Ohana, Kimura and Chitaley, gen. et sp. nov. Drawn from Figure 2-1 (holotype). **1B**: *Keraocarpon masatoshii* Ohana, Kimura and Chitaley, sp. nov. Drawn from Figure 5-1 (holotype).

are apocarpous and conduplicate, typically 2.4 cm long and 2.0 mm wide (Figure 2-2), and circular or oblong, 1.5-2.0 mm in diameter, in transverse section (Figures 2-5, 6; Figure 3-5). Terminal of follicle with obtuse end is polygonal in transverse section (Figure 3-4). Wall of follicle consists of outer and inner layers and has a distinct adaxial median suture which is flanked on either side by a ridge, 150 μ m high, forming an adaxial crest pair with minor projections (Figure 3-5). Each follicle has a single abaxial vascular bundle (Figure 2-5, 6; Figure 3-5). A pair of bundles is present in the adaxial crest. In addition, subordinate lateral bundles are present on the outer layer of the follicle wall (Figure 3-5). Spine-like projections are observed on the outer surface of inner follicles where walls are thinner (Figure 2-6).

Stalks: Each follicle has a stalk, 6.0-8.0 mm long and 0.6 mm in diameter (Figure 2-2C; penetrates inside). In longitudinal section, this stalk is inserted into the receptacle (Figure 3-1). In transverse section, it has a large central pith, collateral bundles, and thin inner and thick outer cortices (Figures 3-3, 4). The bundles consist of vascular elements with scalariform thickenings (Figures 4-4, 5, 6).

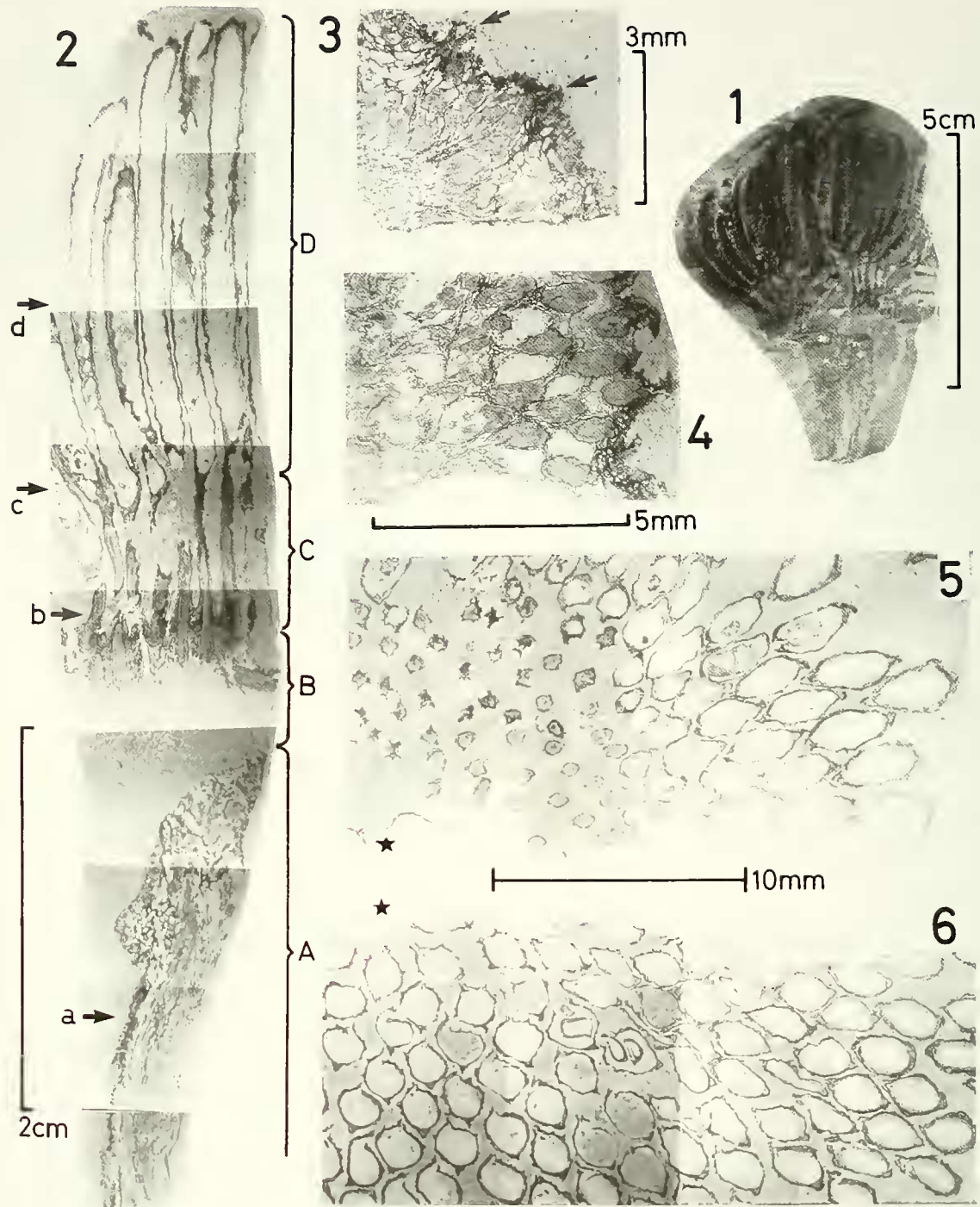


Figure 2. *Keraocarpon yasujii* Ohana, Kimura and Chitaley, gen. et sp. nov. 1. A permineralized fruit (holotype). Its counter part is missing. 2. A nearly radial longitudinal section of peduncle (A), poorly preserved receptacle (B), stalk of follicles (C) and apocarpous follicles (D). Surface of receptacle is slightly convex (composite photographs). 3. A part of a transverse section of the peduncle, cut at 'a'-level in Figure 2-2 showing two sclerenchymatous ribs (arrows). 4. Transverse section cut slightly above the receptacle (at 'b'-level in Figure 2-2). Vacant areas show the spaces among the proximal parts of stalks. 5. Transverse section cut at 'c'-level in Figure 2-2, showing proximal parts of follicles (right side) and stalks (left side). In this section, stalks (C) correspond to the convex centre of receptacle. Centre of this fruit in this section is marked by the star. 6. Transverse section of follicles each with adaxial suture, cut at 'd'-level in Figure 2-2. The centre of this fruit in this section is also indicated by a star.

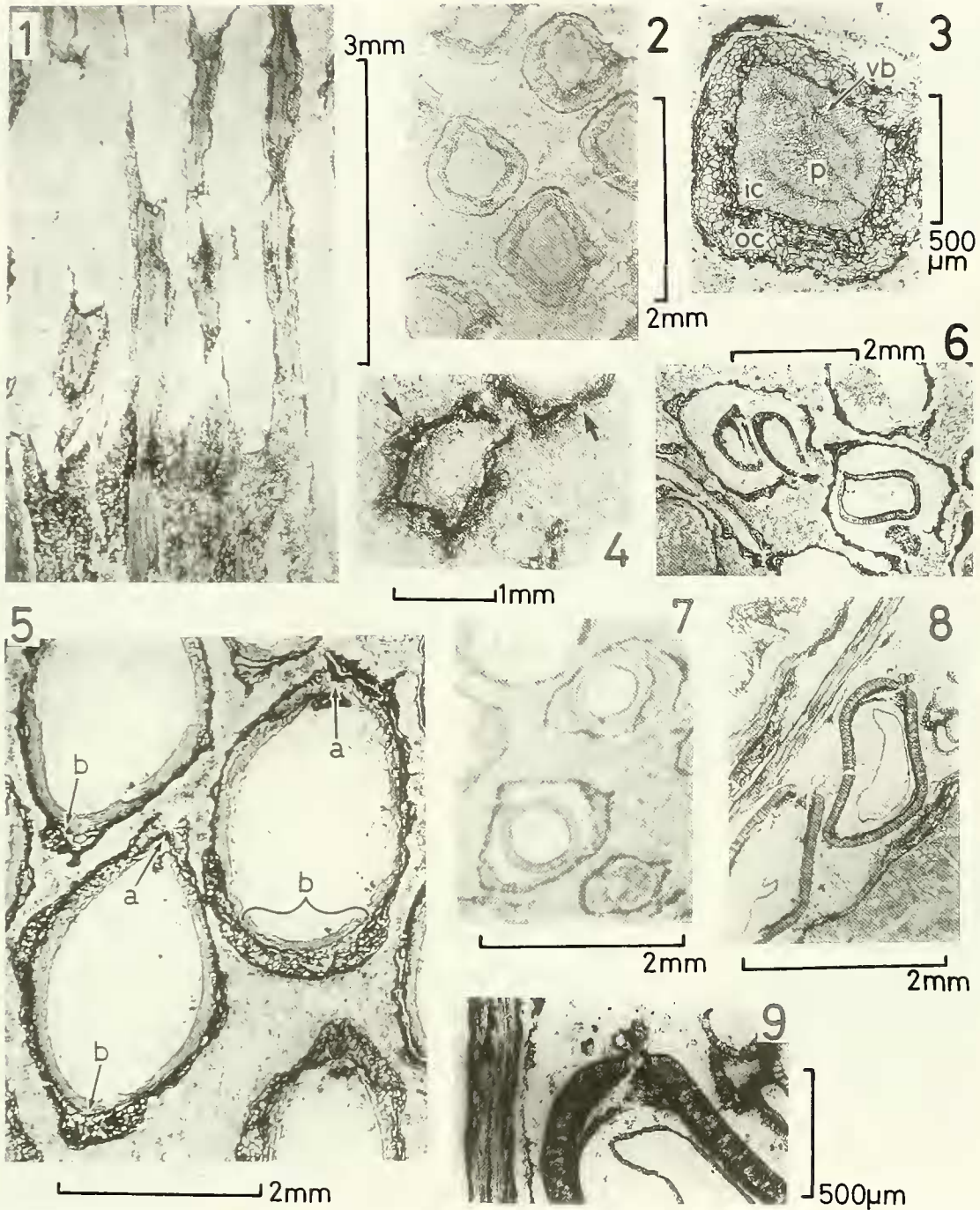


Figure 3. *Keraocarpum yasujii*, Ohana, Kimura and Chitale, gen. et sp. nov. 1. Longitudinal section of stalks. 2. Transverse section of stalks. 3. Enlarged from Figure 3-2. Each stalk consists of thick outer cortex (oc) with large cells and oil-glands, inner cortex (ic) with small cells, vascular bundle (vb) and pith (p). Pith cells are similar to those of inner cortex. Cells of outer cortex are similar to those of receptacle. 4. Transverse section of apical parts of two follicles (arrows). Seeds are absent. 5. Transverse section of middle part of follicles with adaxial sutures facing upper side (arrow a), and abaxial thick bundles (arrow b). Two thin layers are seen in the transverse section of follicle walls. 6. Transverse section of middle part of follicles with remains of seed coats inside. 7. Transverse section of proximal part of follicles, showing the follicle walls and seed coats. 8. Longitudinal section of a follicle with two thick seed coats. 9. A thick seed coat, enlarged from Figure 3-8.

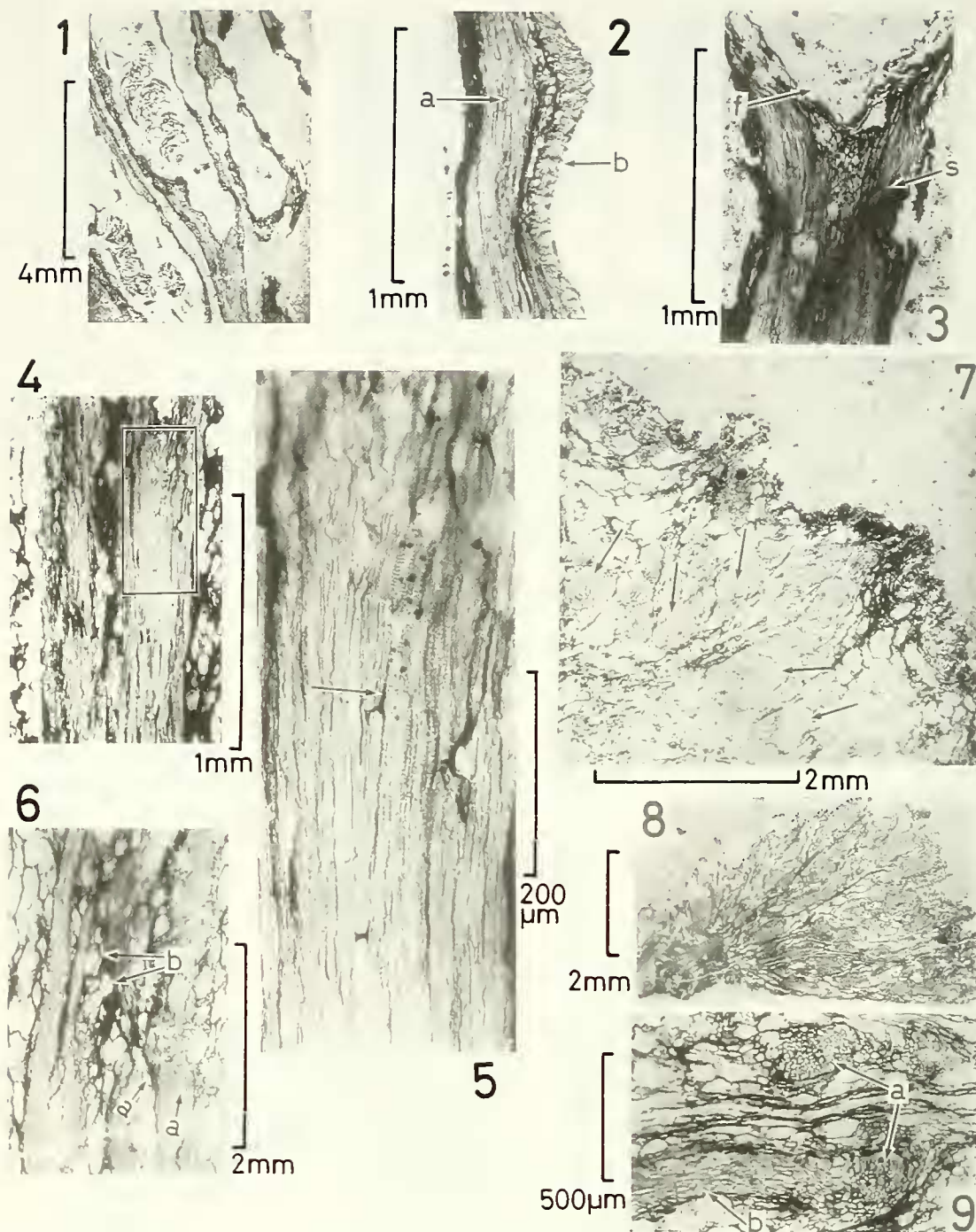


Figure 4. *Keraocarpum yasujii* Ohana, Kimura and Chitaley, gen. et sp. nov. **1.** Longitudinal section of proximal part of follicles, each with disintegrated seeds. **2.** Longitudinal section of the follicle wall (outer layer; arrow a, inner layer; arrow b). **3.** Longitudinal section of a stalk (arrow s) and the base of follicle chamber (arrow f). **4.** Longitudinal section of an enlarged stalk, showing scalariform bundles. **5.** Enlarged from the boxed area of Figure 4 4. Scalariform bundles are clearly seen (arrow). **6.** Tangential section of basal part of peduncle with eustele bundles (arrow a), showing the alternation of bundles and parenchymatous tissues (including oil glands) (arrow b). Pith is located to the right side. Phloem is not preserved. **7.** Transverse section of the basal part of peduncle, enlarged from Figure 2-3. Arrows indicate the eustele bundles. **8.** Transverse section of a part of receptacle, showing fibrous and crowded bundles. **9.** Enlarged from a part of Figure 4 8, showing vertically (arrow a) and horizontally oriented (arrow b) bundles.

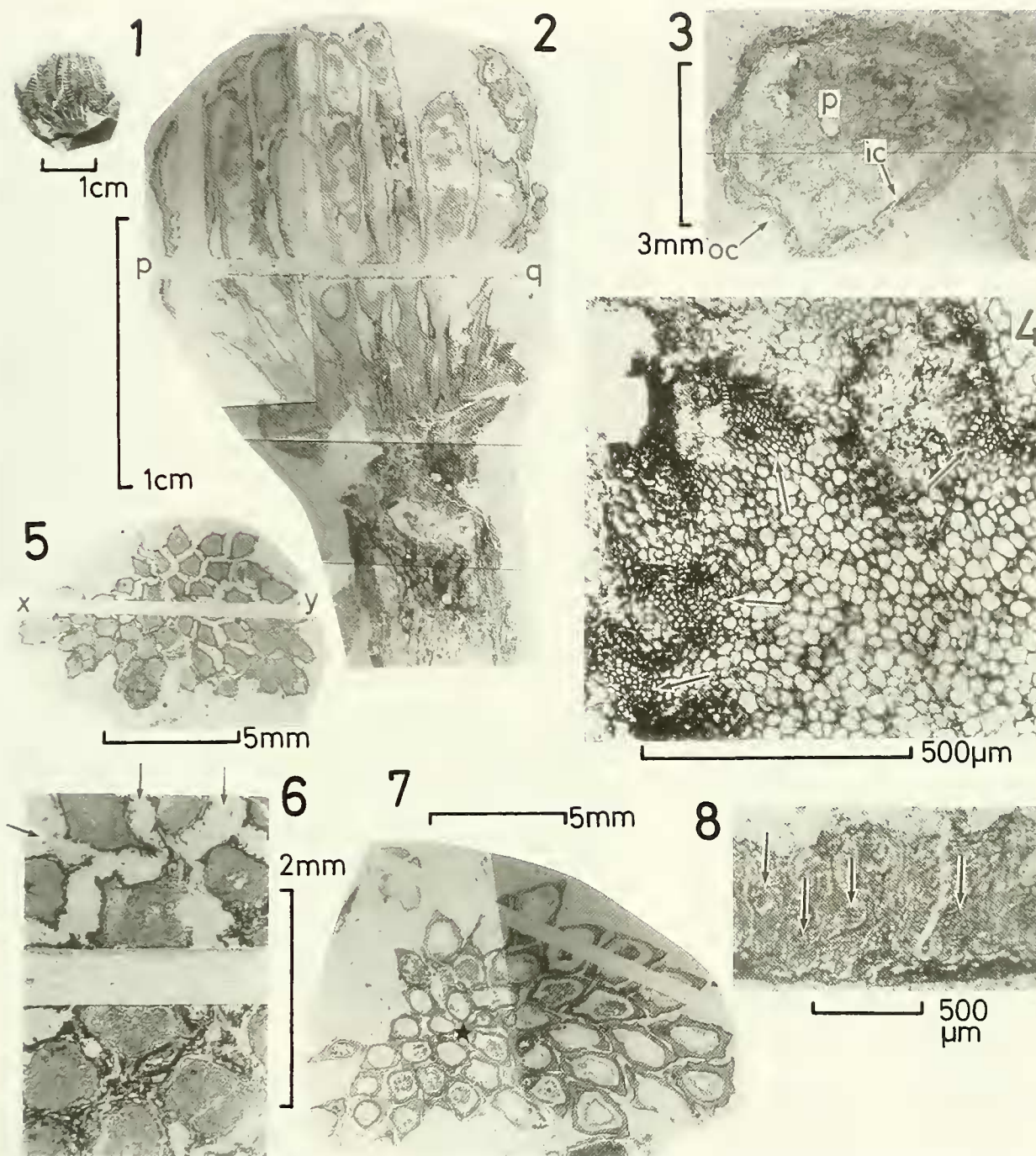
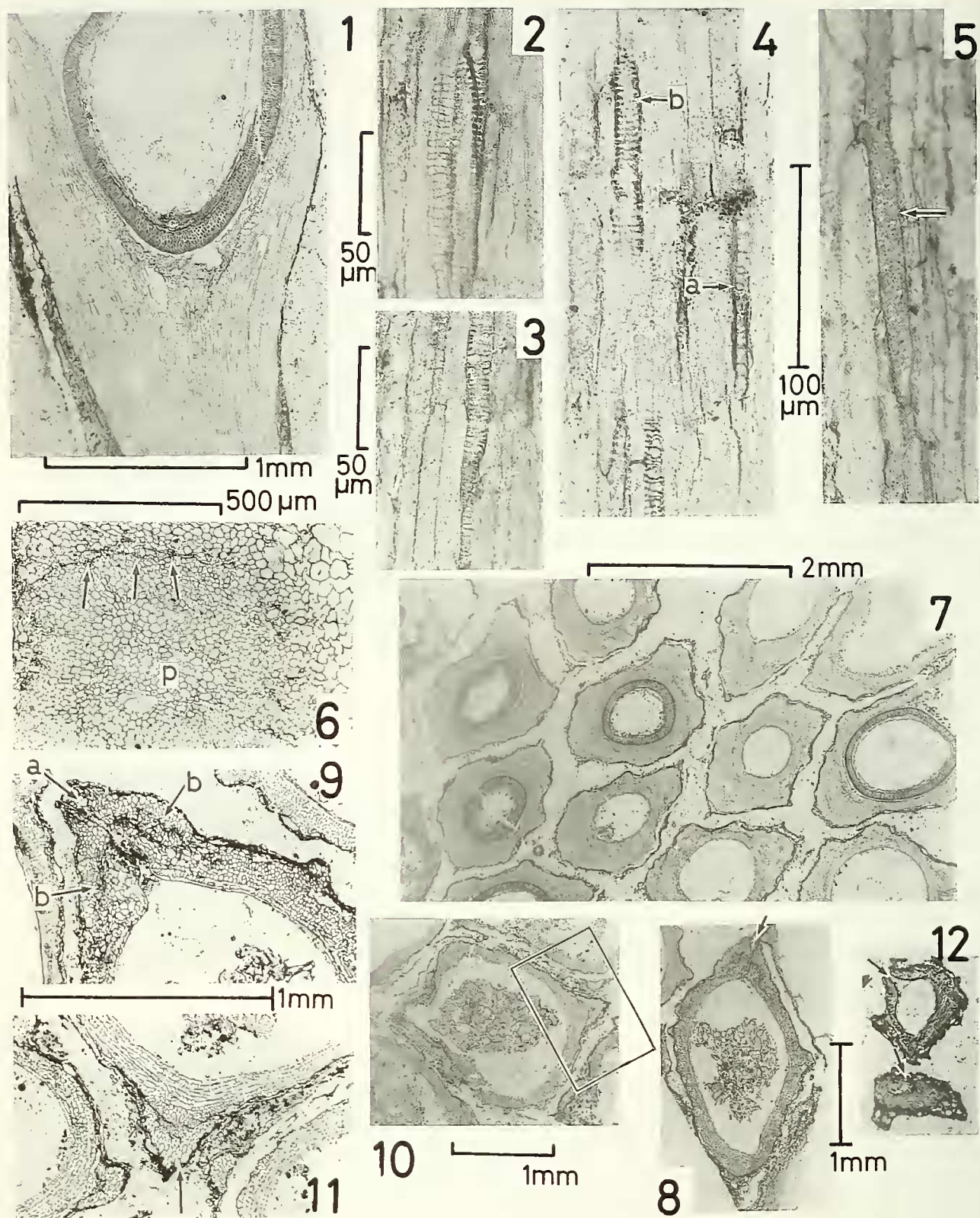


Figure 5. *Keraocarpou masatoshii*, Ohana, Kimura and Chitaley, sp. nov. **1.** Preserved parts of small aggregate fruit (holotype; compare with *Keraocarpou yasujii* shown in Figure 2-1). **2.** Radial longitudinal section of an aggregate fruit, consisting of poorly preserved peduncle, receptacle and apocarpous follicles each with distinct stalk. **3.** Transverse section of peduncle, showing large pith (p), collateral vascular bundles, inner cortex (ic) and thick outer cortex (oc). **4.** Enlarged from Figure 5-3, showing pith and collateral vascular bundles (arrows). **5.** Transverse section of stalks. x-y; zone lost by cutting (using a 0.4-mm-thick saw). **6.** Enlarged from Figure 5-5, showing polygonal or irregular outline of stalks. Arrows indicate openings filled with rock matrix. **7.** Transverse section of apocarpous follicles. Wall thickness varies according to the cutting plane. The adaxial suture faces the supposed centre of the fruit (star). **8.** Tangential section of edge of receptacle, showing horizontal vascular bundles (arrows).



Seeds: The follicle is unilocular with seeds alternately arranged in two rows, 21–24 in number in each follicle (Figure 3–6–9). Seed coat is thick with micropyle facing the adaxial suture of the follicle (Figure 3–6–9).

Keraocarpon masatoshii Ohana, Kimura and Chitaley, sp. nov.

Figures 1B, 5, 6

Specimen.—INH-021 (Holotype).

Locality.—Upper course of the Ikushunbetsu River bank, Mikasa City (4 km south of the Kumaoizawa locality where *Keraocarpon yasujii* was collected.)

Horizon.—Same as *K. yasujii*.

Etymology.—After Masatoshi Kera, collector of the holotype.

Specific diagnosis.—An aggregate fruit of follicles, small. Receptacle slightly convex. Number of follicles around 70. Stalk and wall of follicle thick. Seeds in each follicle, 15–18.

Description.—Preserved parts of this fruit are a permineralized peduncle, receptacle and apocarpous conduplicate follicles (Figures 1B, 5–1).

Peduncle: Peduncle is 5.5 mm in diameter, consisting of pith, collateral vascular bundles and cortex (Figure 5–2–4).

Receptacle: Receptacle is slightly convex disk-like, 1.0 cm in diameter and 3.5 mm thick.

Follicles: The follicles are helically arranged; their estimated number is 70. Since half of them are missing, the parastichy is uncertain. The follicles are apocarpous and conduplicate, 1.1 cm long, with transverse section circular or sometimes polygonal, 1.5–2.0 mm in diameter (Figure 5–7).

Stalk: 1.0–1.5 mm long and 0.8–1 mm thick, and is inserted into the receptacle to a depth of about 1.8 mm (Figure 5–2). It is circular to polygonal in transverse section, having a pith, vascular bundles and cortex (Figure 5–5, 6). The bundles consist of scalariform vessels and pitted tracheids (Figure 6–

1–5). The follicles are adaxially sutured (Figure 5–7; Figure 6–7–10). The follicle wall consists of two layers of cells, the outer thick and the inner thin. In each follicle, a thick vascular bundle is on the abaxial side, and a pair of adaxial bundles are on either side of the suture. No suture is observed at the proximal part of the follicle (Figure 6–7). Most of the sutures are not fully open, suggesting that its seeds are not fully matured.

Seeds: Seeds are 15–18 in number in each follicle. The seed coat is of two layers (Figure 6–1, 7). There is almost no space between the seed and the inner wall of the follicle.

Remarks.—This species is distinguished from *K. yasujii*, the type species of *Keraocarpon*, by the smaller sizes of peduncle, receptacle, and follicle and the smaller numbers of follicles, and seeds in each follicle. The transverse section of follicle is not rhomboidal as illustrated by Nishida *et al.* (1996) in their *Hidakanthus*, but elliptical or polygonal (in this work). In both fruits no male organs or other vegetative parts have been found in organic connection.

The Upper Yezo Group of marine origin contains many varied type of fossil plants. It is, however, difficult to get entire or nearly entire plant specimens, because these terrestrial plants were disaggregated in the course of taphonomy.

Acknowledgements

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← **Figure 6.** *Keraocarpon masatoshii* Ohana, Kimura and Chitaley, sp. nov. **1.** Longitudinal section of a thick stalk. Its upward extension forms follicle wall to wrap a proximal seed. No adaxial suture is present below the position of the proximal seed. **2.** Scalariform vessels in the stalk enlarged from Figure 6–1. Some perforation plate of vessels are scalariform. **3.** Same, enlarged from Figure 6–1. **4.** An annular tracheid (arrow a) and scalariform vessels (arrow b) in stalk enlarged from Figure 6–1. **5.** Pitted tracheid. Pits are in two rows (arrow) enlarged from Figure 6–1. **6.** Transverse section of proximal part of a stalk, showing pith (p) and small collateral bundles (arrows). **7.** Transverse section of follicles, cut along the p–q line in Figure 5–2, showing thick and irregularly formed follicle walls. **8.** Transverse section cut along the middle part of a marginal follicle. Follicle is transversely rhomboidal and the seed is disintegrated. The position of the adaxial suture is indicated by an arrow. **9.** Transverse section of a follicle cut slightly above the section as in Figure 6–8, showing adaxial suture (arrow a). The vascular bundles are seen at each crest (arrow b). **10.** Transverse section of a central follicle, cut at the same level as in Figure 6–8, showing the wall. **11.** Enlarged from the boxed area of Figure 6–10, showing the abaxial bundle (arrow) and thick-layered follicle wall. **12.** Transverse section of apical part of two follicles with distinct adaxial sutures (arrows). The walls are irregular in form.

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